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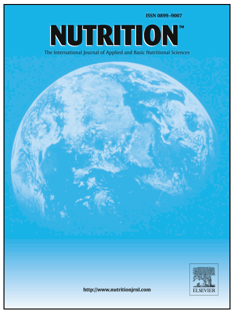

Dietary patterns, digestive symptoms and health-related quality of life in women reporting minor digestive symptoms

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Dietary patterns, digestive symptoms and health-related quality of life in women reporting minor digestive symptoms

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Authorship

BH was involved in the dietary analysis, interpretation of the results and preparation of the manuscript. DP, DG and BT designed the study and were involved in the analysis and the preparation of the manuscript. FHR and PR were responsible for the statistical analysis and commented on the manuscript. KW and BF advised on the analysis and interpretation of the results and preparation of the manuscript. All authors read and approved the final manuscript.

ABSTRACT

Objective

Digestive symptoms are reported to result from a wide range of dietary components. Dietary pattern analysis is a useful method of considering the entire diet, rather than individual foods or nutrients, providing an opportunity to take interactions into account. The objective was to investigate the relationship between diet, digestive symptoms and health-related quality of life (HRQoL) in women reporting minor digestive symptoms, using a dietary pattern approach.

Research methods

Analysis was performed on dietary and digestive symptoms data collected in France. Females (n=308, aged 18-60yrs) reporting a bowel movement frequency within the normal range (3-21 stools/week) but with minor digestive symptoms in the previous month were investigated. Dietary data was collected using three 24-hr recalls. K-means was used to divide the dietary data into clusters. The frequency of digestive symptoms (abdominal discomfort or pain, bloating, flatulence, borborygmi) and bowel movements were evaluated over a two week period. HRQoL was also assessed.

Results

Four dietary clusters were identified and characterized as: Cluster 1 ‘*Unhealthy*’, Cluster 2 ‘*Balance*’, Cluster 3 *‘Healthy’* and Cluster 4 *‘Convenience’*. Analysis showed no differences in the frequency of digestive symptoms according to dietary cluster, except for flatulence (p=0.030) which was more frequent in the *Unhealthy* and *Convenience* clusters. No significant differences were observed in HRQoL according to dietary clusters.

Conclusions

Our results demonstrate that even within a relatively homogeneous sample of French women, distinct dietary patterns can be identified but without significant differences in digestive symptoms (except for flatulence), and HRQoL.

INTRODUCTION

Dietary patterns are multiple dietary components operationalized as a single exposure. They allow the meaningful representation of the entire diet rather than individual foods or nutrients, providing an opportunity to take into account any interactions and/or confounding factors between foods and/or nutrients. The approach recognizes that free-living individuals consume foods in combination and is particularly relevant when investigating diet-disease relationships in nutritional epidemiology.[1-4] One method to establish dietary patterns is assessing the alignment of an individual's diet with pre-defined dietary standards (hypothesis driven or *a priori*), however this necessitates knowledge about the health or disease promoting effects of dietary components that are limited by current scientific knowledge of such relationships.[2] In contrast, data driven methods that use factor or cluster analysis can detect dietary patterns from existing data with no prior assumptions of health or disease relationships (*a posteriori)*.[1,2]

Studies using cluster analysis indicate that dietary patterns are significantly associated with many disease outcomes or biomarkers, including cardiovascular disease, overweight and obesity and other diseases.[5] One area for which dietary pattern analysis has not yet been undertaken is for digestive symptoms such as borborygmi, flatulence, abdominal discomfort or pain and bloating. These symptoms, which are components of functional bowel disorders (FBD), are the most common gastrointestinal (GI) disorders seen in primary care and gastroenterology clinics. Many healthy people who do not fulfil the criteria for FBD[6] frequently experience these symptoms.[7-10] Digestive symptoms related to GI gas production, such as flatulence, are usually among the more frequent symptoms in healthy people.[10] For example, a large community survey in Dutch adults revealed that the prevalence of digestive symptoms was 26% (4315/16,758). Of these subjects, the most frequently reported symptoms were flatulence (71%, 2965/4193), bloating (63%, 2627/4164) and borborygmi (60%, 2479/4138).[11] Digestive symptoms are more prevalent in women and can impair health-related quality of life (HRQoL) and reduce work productivity.[11,12]

Digestive symptoms are reported to result from a wide range of dietary components. For example, some non-digestible carbohydrates undergo colonic fermentation that increases luminal gas production.[13] Furthermore, dietary energy[14] and fibre[15] content can impact on luminal gas dynamics. Therefore, a wide range of dietary components, including fermentable carbohydrates and foods such as legumes, can precipitate digestive symptoms such as bloating and flatulence in patients with irritable bowel syndrome (IBS) as well as in healthy volunteers.[16-20] Indeed, national guidelines recommend that restriction of such dietary components should be undertaken to manage digestive symptoms in IBS.[21]

It may also be assumed that a range of nutrients, food components and their pattern of consumption (e.g. meals vs. snacking) are likely to be relevant to the precipitation of digestive symptoms. It is for these reasons that we conducted the analysis described here which aimed to identify and characterize dietary patterns in a sample of French women, and investigate their associations with digestive symptoms and HRQoL. This research is secondary analysis performed on baseline data collected in a randomized controlled trial designed to investigate the effect of the consumption of a fermented dairy product over 4 weeks on gastrointestinal well-being.[22] To our knowledge this is the first analysis that investigates the relationship between diet and digestive symptoms using a dietary pattern approach.

METHODS

Females aged between 18 and 60 years old, with a body mass index (BMI) within the normal or overweight range (18-30 kg/m^2), and without a clinical diagnosis of any digestive disease including FBD such as IBS were identified from one clinical centre (RPS clinical centre, Caen, France). Subjects were screened to include those reporting minor digestive symptoms in the previous month and a stool frequency within the normal range (3-21 stools per week).[23] A screening questionnaire was used to select people with a minimal level of digestive symptoms (abdominal discomfort or pain, bloating, flatulence and borborygmi), defined as a global digestive symptom score between 8 and 16 or at least one digestive symptom with a score of >4, as previously described.[24] Subjects were excluded from the study if they had any significant systemic disease, if they were prescribed medication for digestive symptoms or if they had ingested antibiotics within the month prior to entry in the study. Individuals with known lactose intolerance or with special dietary habits (e.g. slimming or vegetarian diets) were also excluded.

Subjects visited the research centre and the following key variables were measured: a detailed assessment of dietary intake, assessments of the frequency of four digestive symptoms (abdominal discomfort or pain, bloating, flatulence and borborygmi), an assessment of HRQoL using a Food and Benefit Assessment (FBA) questionnaire,[25] an assessment of bowel movement frequency, physical activity assessment using the International Physical Activity Questionnaire (IPAQ)[26] and height and weight.

Dietary intake and dietary pattern analysis

Food consumption was measured by dieticians using three non-consecutive telephone 24-hour dietary recalls. Where possible, the three recalls were made within a seven day period: two days of data were collected on a weekday and 1 day on a Sunday (recalls were made on Monday for practical reasons). Portion sizes were assessed using household measures, e.g. bowls, cups, spoons. The data was entered directly by the dietician into a web-based tool developed for nutritional epidemiological studies by Medical Expert Systems (MXS, Paris, France). This program was linked directly to a comprehensive French food composition database containing nutritional information on almost 5000 items. Mean food and nutrient intakes were calculated for each subject according to the number of days of dietary data available (in 22 of the 308 subjects analyzed only 2 days of data were available) and group means were generated from these values. Nutrient intakes are based on the consumption of foods only and exclude nutrient intakes from dietary supplements.

Cluster analysis was employed to derive dietary patterns from the data. All food categories were recorded and entered in grams, were standardized to a mean of 0 and a standard deviation of 1 in order to ensure that quantities consumed were comparable across different categories. A comparison of clustering methods for use with dietary data (Ward's Agglomerative Hierarchical Clustering and k-means clustering method) was undertaken prior to this work and has been described elsewhere.[27] K-means was found to be the most appropriate method according to three statistical parameters including the pseudo-F statistic which measures the separation among the clusters at the current level, Sarles cubic clustering criterion (CCC) which tests the hypothesis that the data has been sampled from a uniform distribution on a (hyper) box and the all approximate expected R-squared which measures the variance proportion explained by the clusters. In the k-means method, the number of clusters must be established *a priori* and therefore several solutions were compared with a varying number of clusters (from two to ten). The number of clusters was chosen based on the three statistical parameters described above, pragmatic decisions regarding a good balance of subjects in each cluster and the ease in interpreting the results. The naming of the clusters was carried out by the authors and based on the overall dietary characteristics of the group. Food or drink categories typically high in fat, sugar or salt and low in other nutrients were regarded as ‘less healthy’. Food or drink categories typically low in fat, sugar or salt, higher in fibre and more nutrient dense were regarded as ‘healthier’. Higher or lower intakes (as appropriate) of such categories contributed to the naming of the clusters.

An important aspect of the k-means method is that it does not produce robust results for food categories with extreme values, for example shellfish which are usually consumed infrequently. In order to overcome this, the smallest and largest food category variables were capped at a given value using the winsorized approach which has the advantage of avoiding the need to delete observations from the analysis.[28,29] Using canonical discriminant analysis, a dimension-reduction technique related to principal component analysis and canonical correlation, food categories were transformed into three canonical variables (linear combinations of the interval variables that summarize between-class variation) which enabled the visualization of the food categories that significantly distinguish one cluster from another.

There is a lack of consensus regarding the effect of energy adjustment on the development of the dietary patterns. One study on dietary patterns derived by principal component analysis suggested that energy adjustment is not necessary[30] and therefore this was not performed on this data.

Digestive symptoms and HRQoL

The frequency of individual digestive symptoms (abdominal discomfort or pain, bloating, flatulence, borborygmi) was evaluated twice. Evaluation was carried out on a weekly basis for two weeks using a 5-point Likert type categorization that ranged from 0 (never), 1 (1 day/week), 2 (2-3 days/week), 3 (4-6 days/week) to 4 (every day of the week). The values represent the average frequency over the two week period with rational values rounded up.[24] The FBA questionnaire[25] was developed and validated according to international recognised guidelines used for patient-reported outcomes and aims to assess specifically the benefits of a food or a diet on HRQoL. The questionnaire comprises forty-one items, making it possible to calculate scores for seven dimensions (snacking, vitality, well-being, physical appearance, aesthetics, digestive comfort and disease prevention) over a retrospective two week reference period. The scores range from 0 to 100 with a higher score indicating a higher satisfaction or more positive feeling towards this dimension.

Statistical analysis

Data was analyzed using SAS® 9.2 and SAS® Enterprise Guide® 4.2 (SAS Institute Inc., Cary, NC, USA). All values are expressed as mean ± SD. A p value of less than 0.05 was considered as significant unless specified otherwise, for example where Bonferroni correction was used. Food and nutrient data were not normally distributed and therefore Kruskal-Wallis rank sum tests were used to test for differences between the clusters (unless specified otherwise), while Mann-Whitney tests were used to test for differences between each pair of clusters. The Chi-squared (χ^2) test was used for categorical variables to test for dependence between categories and clusters. The Bonferroni adjustment was applied to the data where multiple comparisons were made for the food consumption and nutrient analyses.

RESULTS

Subject characteristics and identification of dietary patterns

380 subjects were recruited into the study, 324 completed the clinical trial, 16 subjects were removed from the analysis because they had less than 2 days of dietary data (12 subjects) or they were identified during the quality control checks as having implausible intakes for particular foods (4 subjects). Implausible intakes were identified using quality control checks to detect weights so extreme that a recording error was implied. Data for 308 subjects were therefore analysed (81% of subjects recruited and 95% of subjects who completed the study). Based on the food consumption of subjects, the optimal statistical parameters and the number of subjects in each cluster (see Methods), four clusters of dietary patterns (Cluster 1, n=58; Cluster 2, n=94; Cluster 3, n=100, Cluster 4, n=56) were identified (Figure 1). Using canonical discriminant analysis, the food categories that significantly distinguish one cluster from another can be seen in Figure 2.

Subject characteristics for each cluster are given in Table 1. A significant difference was observed in the mean age of subjects; mean age was lower in Cluster 4 (26.3 (7.6) years) compared to Cluster 3 (37.7 (10.3) years). Body Mass Index was significantly different (p=0.037), however after controlling for age this difference was no longer significant (p=0.391, Stratified Kruskal-Wallis test). A greater proportion of current smokers was seen in Cluster 1 (45%) and 2 (38%) compared with Cluster 4 (23%) while the highest proportion of ex-smokers was seen in Cluster 3 (23%). The proportion of post-menopausal women was low (range 0 to 11%).

Dietary patterns and food intake

Mean food intakes of the dietary clusters for all food categories are shown in Table 2. A significant difference across the four clusters was observed for 19 of the 27 food categories. Results are complementary to those presented in Figure 2 and food categories of importance are confirmed. Cluster 1 appeared to be the least healthy cluster and was therefore entitled *'Unhealthy'*, with a higher consumption of cheese, nuts and appetizers, ready prepared and complex dishes, pastries and biscuits, alcoholic and carbonated beverages and a lower consumption of fruits, vegetables, breakfast cereals and dairy desserts such as yogurt. Cluster 2 appeared average in terms of healthfulness compared to the other clusters and was therefore entitled '*Balance'*, with a higher consumption of starchy cereals such as rice, pasta, potatoes and desserts and a lower consumption of salad and raw vegetables, bread and bread products, pastries and biscuits, alcoholic beverages and soups. Cluster 3 appeared to be the most healthy cluster and was therefore entitled '*Healthy'*, with a higher consumption of fruits, vegetables, dairy desserts such as yogurt, soups, coffee and tea and a lower consumption of starchy cereals, cheese, sandwiches, filled pastries and pizza, ready-prepared and complex dishes, milk and carbonated beverages. Cluster 4 appeared to consume more convenience foods or easily prepared foods and was therefore entitled '*Convenience'*. Subjects in this cluster had a higher consumption of bread and bread products, salad and raw vegetables, sandwiches, filled pastries and pizza, breakfast cereals and milk, and a lower consumption of coffee and tea compared to the other clusters.

Dietary patterns and nutrient intake

Table 3 presents the mean absolute nutrient intakes by cluster. Significantly higher absolute intakes of energy and several nutrients including total fat, carbohydrate, folate, riboflavin, thiamin, vitamin E, calcium, iron, magnesium, phosphorus, potassium and sodium were seen in *Convenience*. Significantly higher absolute intakes of beta-carotene were seen in *Healthy*, while fibre intakes were very similar in *Healthy* and *Convenience*. Additional analysis investigating nutrient intake per 1000 kcal revealed that higher intakes were seen in *Healthy*, significantly so for protein, fibre, vitamin A, beta-carotene, niacin, vitamin B_6, folate, vitamin B_{12}, vitamin E, iron, magnesium, potassium, sodium and vitamin C, supporting the characterization that this cluster was the healthier cluster with a more nutrient dense dietary intake (data not shown). Significantly higher intakes per 1000 kcal were seen for carbohydrate, thiamin, riboflavin and calcium in *Convenience*.

Dietary patterns, digestive symptoms and HRQoL

The identified dietary clusters were analysed according to several factors. Figure 3 shows the average weekly frequency of four digestive symptoms (abdominal discomfort or pain, bloating, flatulence, borborygmi) by dietary cluster. Frequency of flatulence was significantly different between clusters (p=0.030, χ^2 test), and more frequent in *Convenience* followed by *Unhealthy*. There were no significant differences in the frequency of the other digestive symptoms across the clusters.

Analysis of the HRQoL questionnaire showed no statistically significant differences overall for the seven dimensions according to the dietary clusters (Table 4).

DISCUSSION

To our knowledge, this analysis is the first to investigate associations between dietary patterns, digestive symptoms and HRQoL. Dietary pattern analysis serves as a complementary approach to more traditional dietary analyses based on individual food and nutrient intake. The results demonstrated that, even within a homogeneous sample of French women, distinct dietary patterns can be identified. We were able to identify and characterize four distinct groups based on statistical parameters and dietary intakes; a less healthy group, *(Unhealthy)*, a starchy/desserts group (*Balance*), a healthy group (*Healthy*) and a convenience group (*Convenience*). The analysis of nutrient intake supported our characterization that *Healthy* was the healthier cluster when nutrient density was taken into account. Our results are in line with results from an analysis of a large population of French adults that identified four dietary clusters using factor analysis. In that study, the four clusters were less healthy (alcohol and meat products), more healthy (prudent diet), convenience foods and starch, sauces and vegetables.[31]

Analysis of the subject characteristics identified some key demographic differences between the clusters. Subjects in *Convenience* were younger while subjects in *Healthy* were slightly older. The proportion of women in the postmenopausal category reflected these age differences across the clusters. We acknowledge that subject characteristics may have confounded the results, however, after adjusting for age (Van Elteren test), minor differences were observed in the significant food groups that characterized the clusters indicating that differences in age did not fully explain the observed differences in food consumption and for this reason the Kruskal Wallis test was used. Clusters *Unhealthy* and *Balance*, contained more current smokers while higher proportions of ex-smokers were seen in *Healthy*, perhaps reflecting a population who have made changes to an overall healthier lifestyle with age. Kesse-Guyot and colleagues also reported higher rates of current smokers in their 'alcohol and meat products' cluster, while the prudent cluster was associated with greater age.[31] The convenience cluster was also associated with a younger age, as observed in our study.[31] Despite similarities observed between our cluster groups and cluster groups reported in other studies, it should be recognized that comparisons between dietary patterns are difficult, especially in those cases where different analytical techniques are used.[32]

Overall the associations between dietary patterns and digestive symptoms were found to be weak for this population. Analysis of digestive symptoms showed that the frequency of flatulence was highest in *Unhealthy* and *Convenience*, the groups consuming less healthy foods and more foods 'on the go' and this result warrants further investigation. From the results in Figure 2 and Table 2, it may be suggested that the higher frequency of flatus found in these clusters might be as a result of the combined effects of higher consumption of fermentable foods including, for example, bread and nuts (*Unhealthy*) or milk and raw vegetables (*Convenience*). An additional consideration is the time period of the assessments for diet, HRQoL and digestive symptoms. Although these assessments covered approximately the same time period, 3 days of dietary data may be insufficient to capture the global dietary habits of subjects and may have contributed to the lack of associations observed between these variables. Future studies of this kind should consider collecting dietary data for more than 3 days, and use a supplementary dietary assessment method capable to capturing habitual dietary habits, such as a food frequency questionnaire.

The representativeness and generalisability of this study should be taken into account when interpreting the results given that the subjects were all female and from only one clinical centre in France and the sample size was relatively small. The selection of subjects is a potential limitation for our analysis since subjects were identified as having *some* digestive symptoms, but were without clinical diagnosis or treatment of FBD. In principle our subjects represent a group of the population in between normal and clinically diagnosed FBD. However, in practice, according to the level of symptoms described by some subjects, a proportion may have undiagnosed FBD. Additionally, the study was designed and powered according to the primary criteria of the randomized controlled trial and it was not possible to undertake a power calculation for the current analysis because data on the association between dietary patterns and digestive symptoms were not available until now.

A further consideration is that the validity of the dietary pattern analysis depends on the dietary assessment method and the accuracy of the dietary data.[2] Dietary pattern analysis requires decisions and interpretations to be made at different stages that may bias the results, including the creation of the food categories used in the analysis, decisions regarding the number of clusters and the naming of the clusters. In addition, the replication of results in other populations is difficult, with patterns only being comparable when food groups and analytical decisions are similar. Similarly named dietary patterns across studies do not ensure comparability. A validation of the dietary patterns identified in this study could be a useful next step. With these considerations in mind, dietary pattern analysis may be a useful approach to help researchers and clinicians understand different sub-groups and develop tailored recommendations, especially since recommendations based on the entire diet are easier to implement and more easily understood by the general population.[2] Despite the lack of associations between diet, digestive symptoms and health-related quality of life (HRQoL) in women reporting minor digestive symptoms in our study carried out in France, dietary pattern analysis remains a useful way to consider the entire diet, rather than individual foods or nutrients. Future studies should consider using this approach which provides an opportunity to take interactions into account and facilitate understanding of dietary habits and the precipitation of digestive symptoms.

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Conflicts of Interest

BH, FHR, BT, DP, DG and PR were employees of Danone Nutricia Research at the time that this work was conducted. KW and BF acted as consultants of Danone Nutricia Research for this research. BF has received consulting fees from Danone, Nestlé, Nutricia, Roquette and Beghin-Say. KW has received research funding, speaker's honoraria or consulting fees from a range of research and charitable bodies, including Broad Medical Research Program, Crohn's and Colitis UK, National Institute of Health Research (UK) as well as industry bodies including Danone, Nestle, Yakult, Californian Dried Plum Board and Clasado.

Ethical Standards Disclosure

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Committee Nord Ouest III (Caen, France). Written informed consent was obtained from all subjects.

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Table 1. Subject characteristics in the four dietary clusters

Characteristic	**Cluster 1 "Unhealthy"**		**Cluster 2 "Balance"**		**Cluster 3 "Healthy"**		**Cluster 4 "Convenience"**		*P*	
	n=58		n=94		n=100		n=56			
Demographics	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Age (years)	33.2	10.2	31.0	10.3	37.7	10.3	26.3	7.6	**<0.001**	*
BMI (kg/m^2)	22.8	2.6	22.9	2.5	23.5	2.7	22.3	2.7	**0.037**	*
Smoking status	n	%	n	%	n	%	n	%		
Never smoked	21	36	47	50	52	52	36	64	**0.005**	†
Ex-smoker	11	19	11	12	25	25	7	13		
Current smoker	26	45	36	38	23	23	13	23		
Activity level	n	%	n	%	n	%	n	%		
Low	9	16	10	11	8	8	11	20	0.532	†
Moderate	27	47	42	45	39	39	21	38		
High	17	29	32	34	34	34	21	38		
Missing	5	9	10	11	19	19	3	5		
Menopausal status	n	%	n	%	n	%	n	%		
Non-menopausal	54	93	88	94	89	89	56	100	‡	
Post-menopausal	4	7	6	6	11	11	0	0		

Significant result for BMI was not observed after controlling for age (p=0.391), Van Elteren test.
* Kruskal-Wallis test
† Chi squared test
‡ No statistical test performed due to distribution of subjects in Cluster 4.

Table 2. Food intake (g/day) in the four dietary clusters

	Cluster 1 "Unhealthy"		Cluster 2 "Balance"		Cluster 3 "Healthy"		Cluster 4 "Convenience"		*P*	
	n=58		n=94		n=100		n=56			
Food category	Mean (g/d)	SD	Mean (g/d)	SD	Mean (g/d)	SD	Mean (g/d)	SD		
Bread and bread products	91.7	44.9	56.7	32.4	94.4	43.5	97.3	52.0	**<0.001**	*§‖
Starchy foods e.g. rice, pasta, potatoes	170.8	75.5	191.3	75.8	120.4	62.8	162.1	59.2	**<0.001**	†§¶
Breakfast cereals	3.4	10.8	7.8	19.0	8.7	18.9	30.3	24.5	**<0.001**	‡‖¶
Pastries and biscuits	104.7	76.9	66.2	59.6	91.5	78.7	100.3	73.5	**0.002**	*
Meat, poultry and offal	145.7	81.6	142.6	90.3	114.9	74.8	121.4	83.3	0.006	
Meat products e.g. ham, mousse, pâte, sausage	51.0	69.0	48.0	42.1	42.2	40.0	46.0	42.0	0.804	
Fish, all types	49.1	68.9	52.4	81.2	79.8	91.2	43.1	70.6	0.013	
Shell fish	38.3	77.8	18.2	60.6	32.0	95.6	6.7	26.3	1.000	
Cheese	51.6	31.2	29.6	22.6	28.2	22.1	43.8	30.6	**<0.001**	*†
Eggs	36.0	63.8	23.8	50.5	24.2	44.1	24.5	49.2	0.758	
Milk, all types	67.7	103.2	92.4	124.9	36.4	79.5	307.6	89.8	**<0.001**	‡‖¶
Oils and fats	12.1	8.9	11.7	6.8	14.1	8.3	15.6	9.3	0.037	
Fruit	156.3	102.5	168.9	115.7	250.5	126.3	199.9	109.7	**<0.001**	†§
Vegetables including pulses	86.9	78.4	124.4	77.0	154.5	103.8	120.0	91.9	**0.001**	†
Salad and raw vegetables	74.4	60.5	50.0	48.1	86.8	79.6	103.5	76.1	**<0.001**	‖
Nuts and appetizers	28.4	25.8	3.2	12.7	3.9	15.1	4.5	11.5	**<0.001**	*†‡
Sandwiches, filled pastries, pizza	71.6	84.6	136.0	106.3	55.7	76.7	145.4	117.2	**<0.001**	*‡§¶
Ready-prepared and complex dishes	185.9	159.7	115.7	169.1	101.0	163.5	116.6	157.5	**0.001**	†
Soups	210.3	285.4	72.2	172.1	364.9	322.5	197.9	274.8	**<0.001**	§
Dairy dessert e.g. yogurt, ice cream, fromage frais	63.8	51.5	86.8	61.1	124.3	91.0	81.2	86.3	**<0.001**	†
Desserts e.g. sorbet, soya dessert	51.7	63.4	95.6	73.3	53.9	85.3	70.8	75.3	**<0.001**	§
Sweets, confectionary, table sugar and jams	19.1	17.6	23.3	19.1	21.8	20.4	25.5	27.3	0.322	
Condiments and sauces	22.7	19.6	21.3	14.5	17.0	14.2	29.6	14.4	**<0.001**	‖¶
Coffee and tea including herbal tea	439.2	307.9	347.3	262.9	656.7	374.8	190.8	195.6	**<0.001**	†‡§‖¶
Carbonated, non-alcoholic beverages	191.1	228.0	113.4	223.8	67.7	137.1	151.9	222.9	**<0.001**	†
Non-carbonated, non-alcoholic beverages	437.5	387.3	465.5	414.9	527.9	458.4	345.4	302.6	0.119	
Alcoholic beverages	224.0	157.9	42.9	84.2	54.5	109.1	105.3	165.0	**<0.001**	*†‡

Means are presented non-winsorized.
SD, standard deviation, *P* based on Kruskal-Wallis test with Bonferroni correction, cut off=0.002, significant results shown in bold.
Significant difference between clusters: * 1 vs. 2, † 1 vs. 3, ‡ 1 vs. 4, § 2 vs. 3, ‖ 2 vs. 4, ¶ 3 vs. 4.

Table 3. Nutrient intake in the four by dietary clusters

	Cluster 1 "Unhealthy"		Cluster 2 "Balance"		Cluster 3 "Healthy"		Cluster 4 "Convenience"		*P value*	
	n=58		n=94		n=100		n=56			
Nutrient (unit/day)	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Energy (kcal/d)	1858.1	397.0	1650.5	360.3	1555.7	350.1	2015.0	446.2	**<0.001**	†‖¶
Protein (g/d)	75.1	16.7	69.6	16.1	69.1	18.9	76.9	17.8	0.010	
Total fat (g/d)	78.4	20.9	68.2	19.3	61.6	15.9	81.7	23.8	**<0.001**	†¶
Carbohydrate (g/d)	194.9	50.5	186.7	49.3	177.7	46.9	236.6	58.4	**<0.001**	‡‖¶
Fibre (g/d)	14.3	4.5	13.6	4.7	17.0	5.2	17.0	4.4	**<0.001**	‡§‖
Vitamin A (µg)	832.8	815.8	705.7	692.1	948.7	898.1	851.3	472.4	0.005	
Retinol (µg)	419.4	751.1	340.8	577.3	360.1	707.3	368.3	299.9	0.005	
Beta-carotene (µg)	1857.3	1715.4	1726.4	1743.9	2891.7	2798.3	2225.9	2009.4	**<0.001**	§
Thiamin (mg)	0.8	0.5	1.0	1.3	0.9	0.3	1.2	0.4	**<0.001**	‡‖¶
Riboflavin (mg)	1.2	0.5	1.2	0.4	1.2	0.4	1.6	0.5	**<0.001**	‡‖¶
Niacin (mg)	14.2	4.7	13.0	4.4	13.8	4.4	14.2	5.0	0.473	
Vitamin B_6 (mg)	1.3	0.4	1.2	0.5	3.2	16.8	1.5	0.7	0.018	
Folate (µg)	219	70.0	187.7	67.6	241.1	81.0	252.5	79.6	**<0.001**	§‖
Vitamin B_{12} (µg)	4.7	5.0	3.7	4.2	4.8	6.2	3.6	1.8	0.016	
Vitamin C (mg/d)	68.1	35.3	74.6	42.7	82.9	45.0	95.3	48.8	0.013	
Vitamin D (µg)	1.9	2.0	1.6	2.0	1.7	2.0	1.6	2.5	0.079	
Vitamin E (mg)	7.4	3.0	6.1	2.4	7.0	2.5	8.2	3.8	**<0.001**	‖
Calcium (mg/d)	748.9	240.3	723.7	239.2	725.1	250.0	986.7	281.4	**<0.001**	‡‖¶
Iron (mg/d)	8.5	2.3	7.4	2.2	8.4	3.3	9.0	2.3	**<0.001**	‖
Iodine (ug/d)	16.8	19.0	11.3	13.7	11.8	10.5	14.2	13.9	0.108	
Magnesium (mg/d)	221.6	55.9	202.8	49.7	232.6	80.1	241.9	55.1	**<0.001**	‖
Phosphorus (mg/d)	933.2	249.5	839.0	197.2	861.3	243.5	1036.3	247.0	**<0.001**	‖¶
Potassium (mg/d)	2096.3	599.5	1966.0	551.2	2226.9	572.3	2373.7	618.0	**<0.001**	‖
Sodium (mg/d)	2921.9	810.5	2387.0	674.5	2796.1	807.4	2964.4	791.2	**<0.001**	*§‖
Copper (mg/d)	0.2	0.1	0.2	0.1	0.2	0.3	0.2	0.1	0.045	
Zinc (mg/d)	1.7	1.1	1.4	1.0	1.5	1.0	1.6	1.0	0.354	

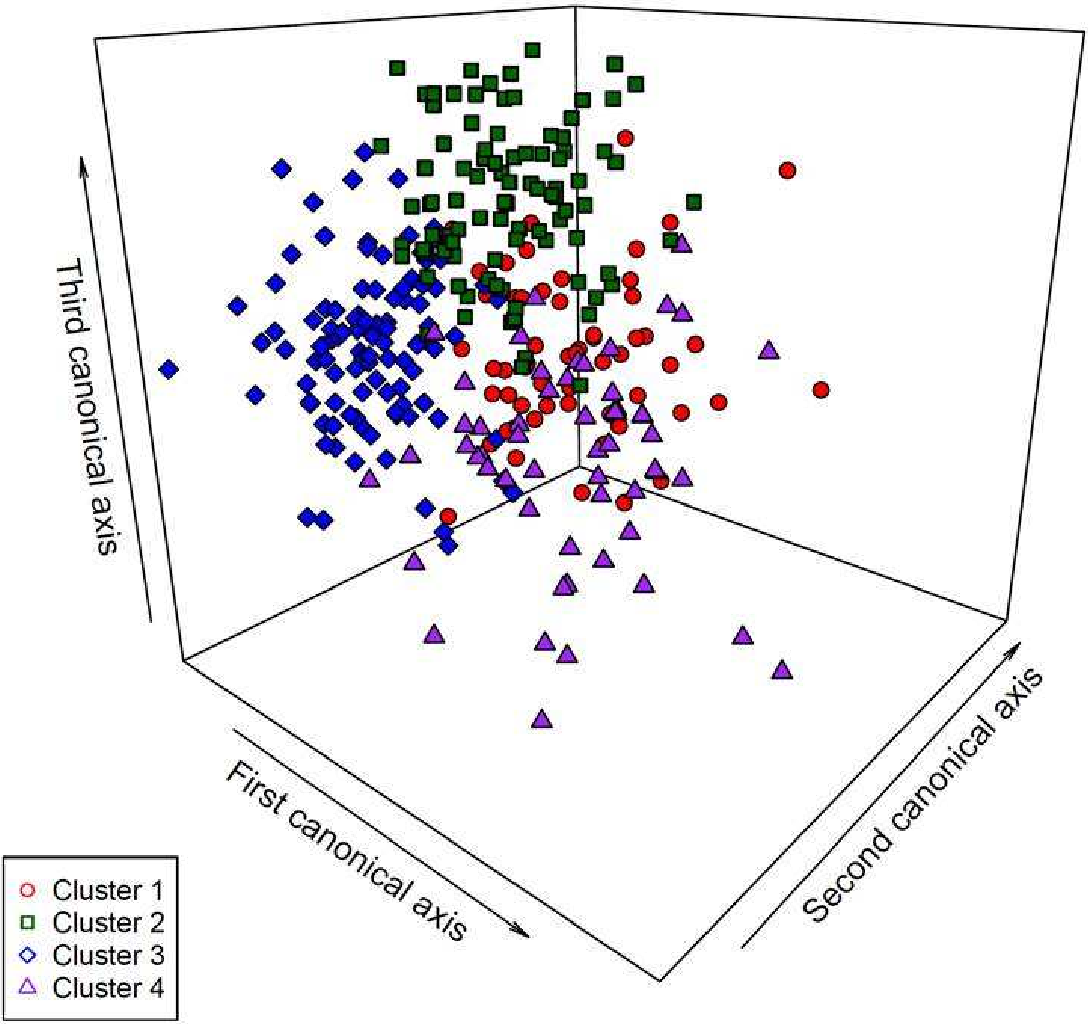
SD, standard deviation; *P*, based on Kruskal-Wallis test with Bonferroni correction, cut off=0.002, significant results shown in bold.
Significant difference between clusters: * 1 vs. 2, † 1 vs. 3, ‡ 1 vs. 4, § 2 vs. 3, ‖ 2 vs. 4, ¶ 3 vs. 4.

Table 4. Health-related quality of life, assessed using the Food Benefit Assessment questionnaire, in the four dietary clusters

Dimension	Cluster 1 "Unhealthy"		Cluster 2 "Balance"		Cluster 3 "Healthy"		Cluster 4 "Convenience"		*P value*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Snacking	61.2	16.1	57.8	17.8	60.8	19.3	57.6	16.5	0.712
Vitality	64.9	12.7	64.8	12.4	67.4	12.3	65.3	13.5	0.541
Well-being	67.2	14.1	68.0	15.5	70.4	16.0	68.9	15.1	0.509
Physical appearance	57.3	22.6	60.2	21.2	58.9	21.4	60.1	21.4	0.931
Aesthetics	61.1	13.6	62.0	15.4	64.2	16.3	62.4	15.2	0.562
Digestive comfort	59.5	13.0	60.9	14.7	63.7	13.0	60.8	13.6	0.277
Disease prevention	77.9	16.9	74.9	16.4	76.7	15.9	80.1	16.3	0.222

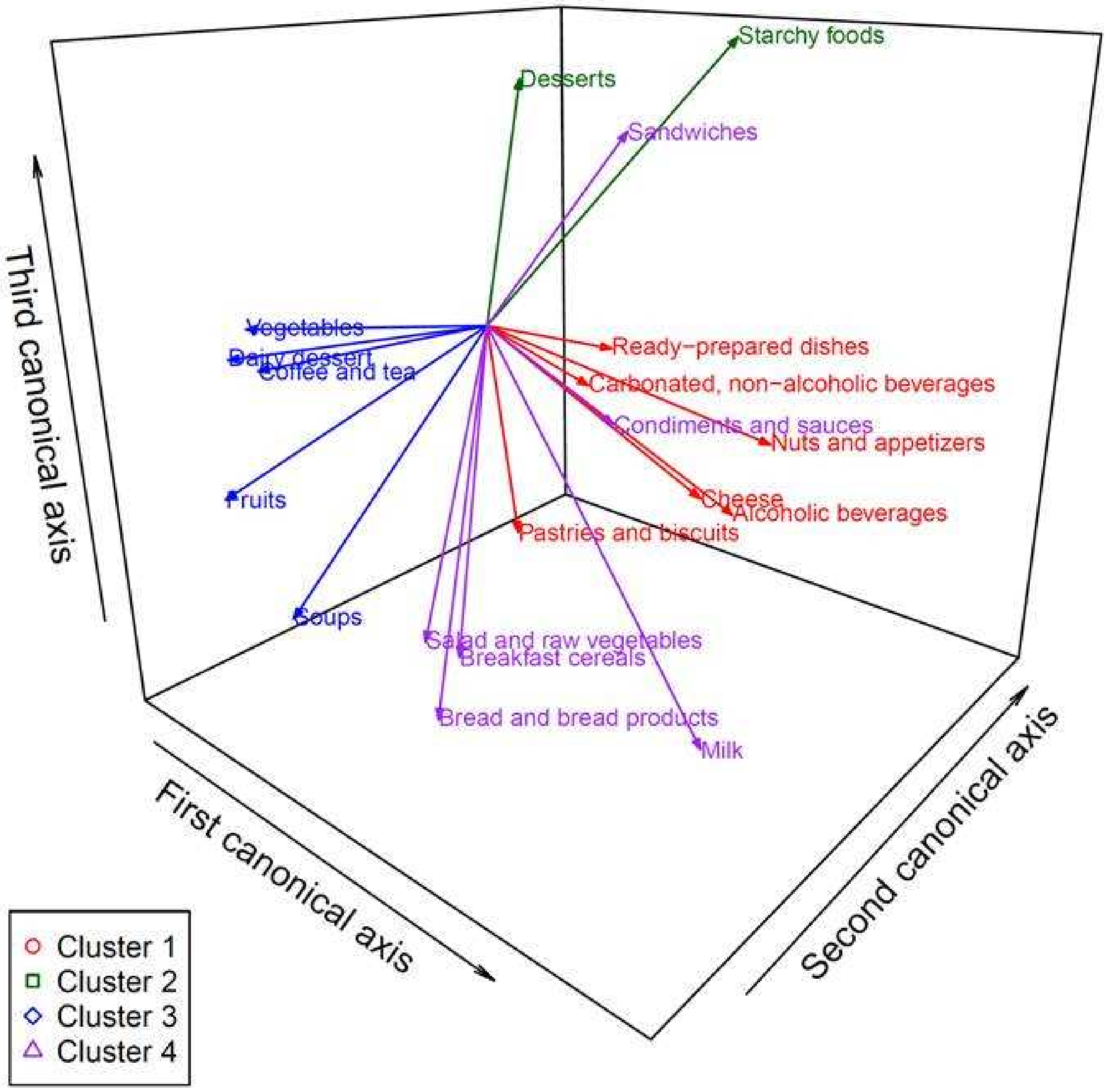
SD, standard deviation,
P value based on Kruskal-Wallis test, cut off p<0.05.

Figure 1. Discriminant canonical analysis displaying the division of the subjects (n=308) in the four dietary clusters.



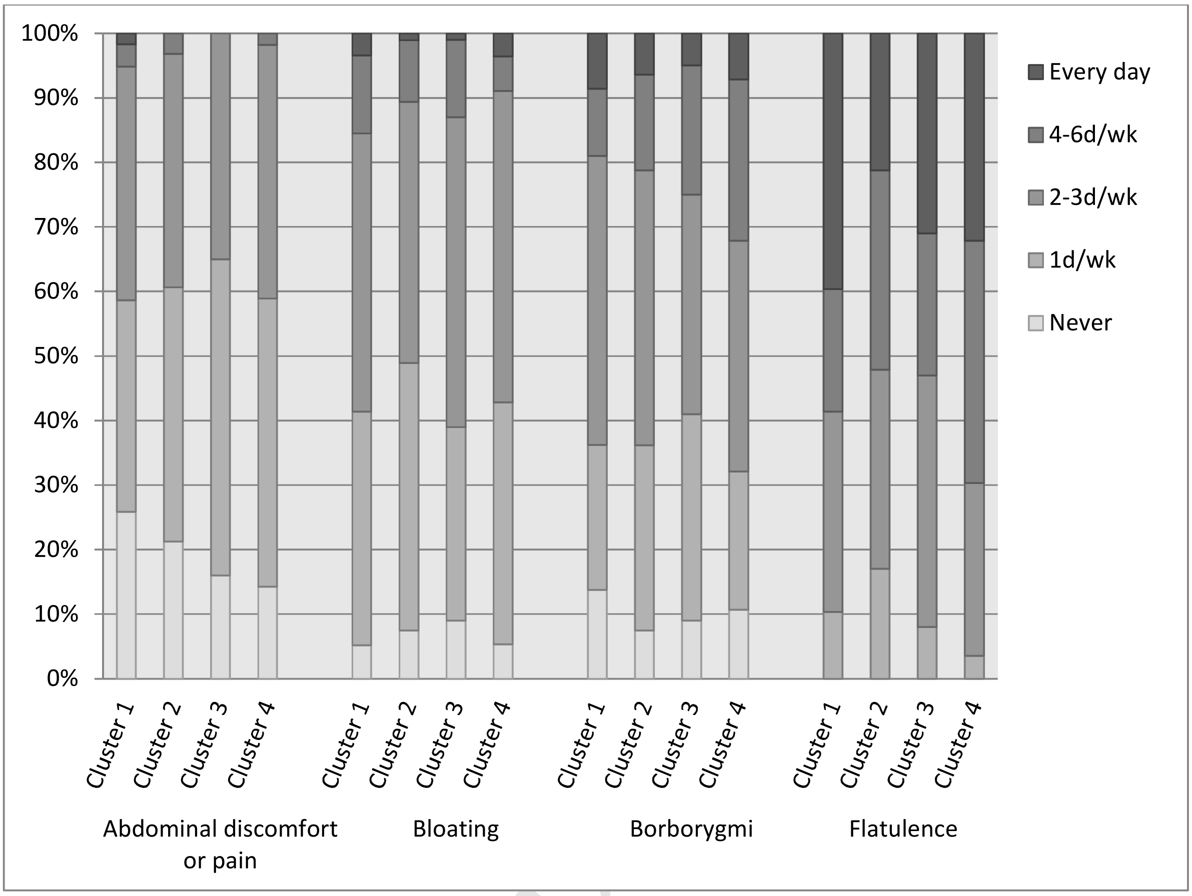
Dietary patterns are Cluster 1 (Unhealthy), Cluster 2 (Balance), Cluster 3 (Healthy) and Cluster 4 (Convenience).

Figure 2. Discriminant canonical analysis: circle correlation showing food categories that create the distinction between the four dietary clusters.



Dietary patterns are Cluster 1 (Unhealthy), Cluster 2 (Balance), Cluster 3 (Healthy) and Cluster 4 (Convenience).

Figure 3. Frequency of digestive symptoms across the four dietary clusters



Symptoms represent the average frequency over a two week period with rational value rounded up. Dietary patterns are Cluster 1 (Unhealthy), Cluster 2 (Balance), Cluster 3 (Healthy) and Cluster 4 (Convenience). Frequency of flatulence p=0.030, χ^2 test

Dietary patterns, digestive symptoms and health-related quality of life in women reporting minor digestive symptoms

Highlights

Four dietary patterns were identified (*Unhealthy*, *Balance*, *Healthy*, *Convenience*)

Flatulence was more frequent in those with *Unhealthy* and *Convenience* dietary patterns

No differences in other digestive symptoms and quality of life between clusters

Dietary patterns are useful to measure the effect of the entire diet on health